

HP UPS R12000 XR technology

technology brief



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Abstract

The online rack Uninterruptible Power Supply (UPS) R12000 XR provides a redundant power protection solution to meet the high-availability demands of today's data centers. The R12000 XR has a significantly higher power rating than previous UPSs; and it is the first online, "N+x" parallel redundant UPS for HP. The fault-tolerant UPS R12000 XR helps customers build a reliable power infrastructure by eliminating system level single points of failure. However, the high-power, hard-wired UPS R12000 XR requires careful site preparation and planning.

This technology brief explains the technologies used in the UPS R12000 XR. It also describes preparation and planning issues customers should consider before installation.

Overview

Crowded data centers and racks filled to capacity with storage devices, monitors, servers communications devices, and other equipment are driving the need for UPSs with increased power density and power efficiency. The UPS R12000 XR is a rack-mountable UPS that provides up to 12,000 watts (W) of power in a 10-U rack form factor. This equates to 1.2 KW per U space, which leads the industry in power density. The UPS R12000 XR uses digital signal processor technology to answer the demands for increased power density and power efficiency.

Designed to meet the high-availability demands of 24x7 business needs, the online rack UPS R12000 XR provides a modular "N+x" parallel redundant architecture, with four 3-kVA¹ modules that are designed to share the load. If a module fails, then the other modules will automatically pick up the load. The N+x parallel redundant architecture enables customers to adapt to growing power requirements and keeps systems powered and protected against bad power.

The UPS R12000 XR also incorporates a unique patented wireless paralleling technology that eliminates system-level single points of failure. Both the logic and the electronics are housed in the individual 3-kVA modules, rather than in the enclosure where most competing UPSs have them. Combined with unsurpassed power density, superior batteries, and enhanced battery management, the fault-tolerant UPS R12000 XR helps customers build a reliable power infrastructure.

The UPS R12000 XR is ideal for customers who seek high availability through redundant power protection solutions, who need to protect rack servers and their infrastructure against bad power and who rely on UPSs to help eliminate system-level single points of failure.

¹ A kVA is 1,000 volt-amperes. A volt-ampere (VA) is a unit of electrical power in an alternating current (AC) circuit equal to the power dissipated when 1 volt produces a current of 1 ampere.

Technology details

The UPS R12000 XR uses a modular design to provide power protection for data centers. Each of the four independent modules in the UPS R12000 XR includes one hot-swappable battery module and one hot-swappable electronics module (Figure 1). If power in the data center fails, the UPS batteries will provide power for connected equipment.

Figure 1. The UPS R12000 XR includes four independent modules each with one hot-swappable battery and one electronics module.



The electronics modules are load sharing, and each module houses its own control logic. The electronics modules are connected in parallel so that maximum load capability of 12,000 W is achieved when operating at full capacity. If maximum reliability is needed, the UPS can operate in parallel redundant mode. When running in redundant mode, if one of the electronics modules fails, the load is shared with the other remaining modules without interruption to the supported load.

The UPS R12000 XR supports up to two extended runtime modules (ERM) to extend battery backup time for power outages. Each ERM is 4U high and comprises two battery packs. When operating at the recommended 80 percent load, each ERM will extend the available battery backup time by up to 15 minutes.

Digital Signal Processor controller

Each UPS module uses a Digital Signal Processor (DSP) controller to monitor and control its own operation.

Originally designed for mathematically and computationally intensive motor drive control processes, DSP controllers now have expanded capabilities such as faster machine-cycle speeds and enhanced programming instruction sets. DSP controller now also offer peripheral functionality such as on-board counters/timers, analog-to-digital converters, pulse-width-modulation outputs, flash memory, and controller-area-network communications. The similarities between motor drive controls and UPS controls combined with the enhanced functionality of DSP controllers contribute to making UPS a natural application for DSPs.

Lower-cost, high-performance DSP controllers provide an improved and cost-effective solution for UPS design. DSPs allow UPS designers to replace bulky transformers, relays, and mechanical bypass switches with smaller, more intelligent functional equivalents. DSP implementations also facilitate other design benefits, including increased power efficiency and increased power density.

In UPS applications, the DSP has integrated functions selected for sophisticated, embedded controls. These functions, previously available only through more expensive microcontrollers and off-board peripheral circuitry, include protection circuitry, clocks, and serial communications in addition to the peripheral DSP functionality mentioned earlier. Except for signal conditioning and actuators that provide the interface between the DSP and the power circuitry, all of the control implementations are digital. Multiple control algorithms can execute almost simultaneously and at high machine-cycle speeds for unprecedented dynamic performance. The DSP implementation also has fewer parts, increased reliability, and greater immunity to noise than predecessor microcontroller implementations. Since the DSP feedback and control loops are implemented digitally, compensation for component tolerances and temperature variations of feedback elements is no longer necessary. DSP technology provides a cost-effective alternative to control multiple power converters, either individually or in combination, to meet the demands of advanced power topologies.

The DSP controller manages many UPS functions, including:

- Sensing and controlling input and output voltage and current levels.
- Setting and controlling the rectifier (a boost converter) for input power factor correction and for regulating the DC voltage in the inverter.
- Setting and controlling the inverter (a buck converter) for output voltage and frequency regulation.
- Controlling the battery charger.
- Interfacing with power management software through communication port cards.
- Switching to electronic bypass.

Power conditioning, efficiency, and battery management

The DSP controller provides the mechanism for the UPS R12000 XR to achieve its unity rating. When apparent power (VA) equals true power (W), the UPS is said to be unity rated. The unity-rated UPS R12000 XR is more efficient and provides improved power flow and thermal management than UPSs that are not unity rated.

The UPS R12000 XR uses online technology, which means that the inverter is on at all times providing power to the load. This is accomplished using a process called double conversion. The online UPS converts the incoming facility alternating current (AC) power (including sags, surges, spikes, noise) into DC power that is then converted into clean, filtered, and constant AC voltage output at a preset value, ensuring reliable, conditioned power feeding connected servers and other IT equipment. If a failure has occurred and the batteries have been used, the intermediary DC voltage is used to recharge them upon recovery.

UPSs from HP incorporate enhanced battery management—an exclusive, patented technology that doubles battery service life, optimizes battery recharge time, and provides advanced notice of pending battery failure. This technology provides a means to constantly monitor the battery and provide advanced warning of pending battery failure before the load is placed at risk. In addition, this technology provides several tests to determine battery health. The data gathered from the tests provide a health indicator to predict battery time remaining and end of life for the battery.

N+x parallel redundant architecture

The UPS R12000 XR meets rigorous redundancy and fault-tolerant requirements. The N+x parallel redundant architecture provides a combination of four 3-kW/3-kVA modules running in parallel, where “x” is the number of reserve modules should a module fail. And should one of the modules fail, the remaining modules seamlessly redistribute the new load requirement through an automatic load-sharing process.

An enhanced, seven-language front-panel LCD display allows customers to configure redundancy for the R12000 XR. The R12000 XR supports the following N+x redundant configurations:

- 12-kW (N+0) – The R12000 XR has a 12-kVA/12-kW rating in an N+0 configuration in which all modules support the load without redundancy. In an N+0 configuration, no module is in reserve.
- 9-kW (N+1) – The UPS can be configured as a 9-kVA/9-kW UPS in an N+1 redundant mode. In an N+1 mode, one 3-kVA module is paralleled for redundancy in case another module fails.
- 6-kW (N+2) – The UPS can be configured as a 6-kVA/6-kW UPS in an N+2 redundant mode. In an N+2 mode, two 3-kVA modules are paralleled for redundancy in case the other two modules fail.
- 3-kW (N+3) – The UPS can be configured as a 3-kVA/3-kW UPS in an N+3 redundant mode. In an N+3 mode, three 3-kVA modules are paralleled for redundancy in case the remaining module fails.

Wireless paralleling

Wireless paralleling is a unique, patented, state-of-the-art technology that allows all four 3-kW/3-kVA modules to function independently of each other. In a “peer” configuration, as opposed to “master-slave” configuration, the wireless technology ensures that each module operates independently.

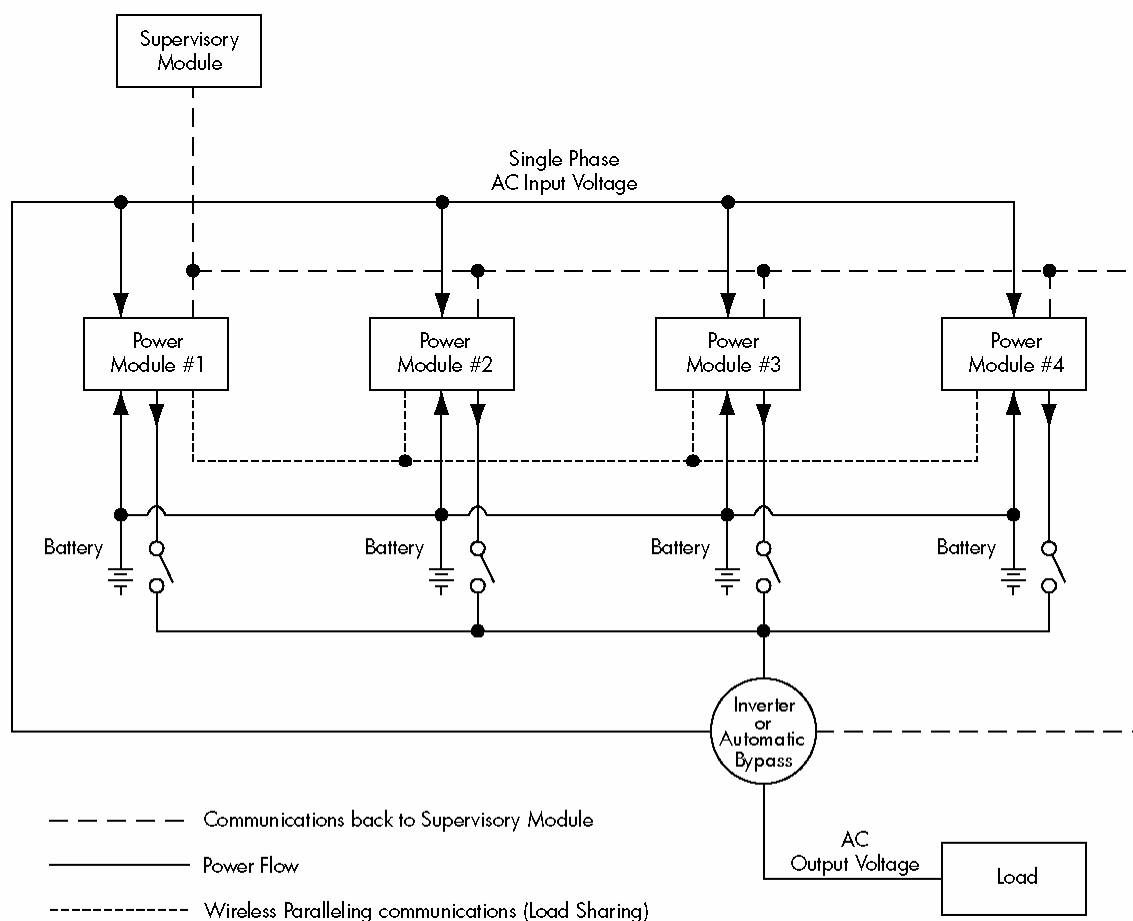
In a traditional parallel UPS system, load sharing required communications wiring between the modules, which introduced single points of failure (that is, if any part of the communication link failed, so did the system).

With its high-speed DSP design, the wireless technology in the UPS R12000 XR enables paralleling for redundancy with no intermodule communication. Each module houses its own control logic, and all necessary information for paralleling is available using only the modules’ output power wave form. The load-share control algorithms maintain synchronization and load balance by constantly making minute adjustments to variations in the output power requirements.

Using a mathematical firmware approach to paralleling for redundancy eliminates the single points of failure that exist with communication wiring and added circuitry between the modules. Therefore, the 100 percent mathematical firmware is more reliable than traditional paralleling that uses communication wiring between modules. In addition, the elimination of intermodule communication also eliminates transfer time in shifting the load from one module to another, should a module go offline for any reason.

Figure 2 illustrates the flow of communications within the UPS. The supervisory module is the brain of the UPS. It monitors the UPS status and reports the information to the front panel and software interface, and it manages power-up and power-down sequences, enhanced battery management, and automatic bypass control. If the supervisory module fails, the UPS will shift to battery power to support the load. This eliminates the supervisory module as a single point of failure and enables the supervisory module to be hot swapped.

Figure 2. Communication within the UPS R12000 XR



Hot-swappable battery and electronics modules

With hot-swappable battery and electronics modules, the UPS R12000 XR brings ease of maintenance to new levels. When batteries reach the end of their useful life, replacement is easy with hot-swappable batteries. With simple access through the front panel, users can safely install new batteries without powering down connected servers and server options.

In addition, the UPS R12000 XR incorporates a bypass switch for servicing the UPS without powering down protected equipment. A flashable microprocessor allows firmware upgrades via the communications port. In addition, the modules and supervisory board are flashable while online and supporting a load. Field service personnel can upgrade the UPS without removing and replacing the hardware or bringing down the load.

Remote Emergency Power Off port

The UPS R12000 XR includes an isolated Remote Emergency Power Off (REPO) port. When connected to a remote switch, the REPO port allows administrators to turn off the UPS from a remote location. Connecting to a remote switch is optional, and, to be functional, the UPS must be connected to a remote switch that is normally open. When this switch is closed, the UPS immediately disconnects power to its loads. The REPO switch is used with a main disconnect device that removes the AC source from the input of the UPS.

If the remote switch is closed, the REPO feature immediately turns off protected devices and does not use the orderly shutdown procedure initiated by HP power management software. The REPO feature shuts down UPS units operating under either utility or battery power. To power down an entire network in the event of an emergency, the REPO ports of multiple UPS units can be connected to a single switch.

HP Power Manager software

The DSP controller interfaces with power management software, such as the HP Power Manager, which provides an easy-to-use browser interface for managing and monitoring attached UPSs. HP Power Manager is an advanced, customizable UPS utility that has been designed to provide information about power conditions, health, and status of the UPS and power environment.

HP Power Manager works with the R12000 XR to increase stability and security in the data center with automated policies based on power and environmental alarms. With the HP Power Manager, administrators can establish power failure policies to provide automatic response to power faults or security risks. The software allows administrators to prioritize shutdowns in the event of a power failure to ensure that data and hardware are fully protected. In addition, the software provides the ability to delay restart based on defined load segments after a shutdown to sequence the startup of system components and perform UPS diagnostics to ensure the availability of adequate battery backup times.

Refer to www.hp.com/products/ups for more information on HP Power Manager.

Modes of operation

The UPS R12000 XR is an online UPS. That means that during normal operating conditions, the UPS is always on and supplying conditioned power to the load through an inverter or converter that constantly controls the AC output of the UPS, regardless of the utility line input. In the event of a utility power failure, there is no delay or transfer time for backup power. An online UPS protects against all types of power problems and continuously uses the inverter to create clean, new regulated power.

The UPS R12000 XR includes a liquid crystal display (LCD) and light-emitting diodes (LEDs) on the front panel that illustrate the normal operating modes and provide warning indicators (Figure 3). The UPS R12000 XR has five modes of operation, indicated by the LEDs on the control panel. Table 1 identifies these modes of operation and the corresponding LED activity.

Figure 3. The LCD and LEDs on the front panel of the UPS R12000 XR identify operating modes and provide troubleshooting indicators.



Table 1. Operating modes and LED indicators for the UPS R12000 XR

Mode	LED activity	Operational result
Normal operation	LED 1 is green and on steady.	Power is available at the UPS output. The UPS monitors and charges batteries.
Standby mode (utility power)	LED 1 is green and flashing.	Power is not available at the UPS output. The UPS monitors and charges batteries.
Standby mode (battery power)	LED 2 is amber and flashing.	Power is not available at the UPS output. Batteries are not being charged. Shutdown is underway.
Battery mode	LED 2 is amber and on steady.	Power is available at UPS output. Batteries are not being charged. Shutdown is underway.
Bypass mode	LED 3 and LED 4 are amber and on steady.	Alarm is sounding. Power is available at the UPS output. Batteries are not monitored or charged.
N+1 mode	LED 5 is green and on steady.	Power is available at UPS output. The UPS monitors and charges batteries. Two or more submodules are working.

Planning and preparation

The UPS R12000 XR is a complex electrical device that requires the highest levels of safety awareness from installers and operators. From unpacking to installation, anyone working with this device should take all precautions to prevent personal injury or damage to the device.

The UPS R12000 XR requires a single-phase 200-240 VAC, 100-amp input service (utility). The input and output must be hardwired by a licensed electrician. In addition, any optional ERMs must be wired to the UPS by a licensed electrician. The unit requires a 100-A circuit with overcurrent protection. The unit weighs 420 pounds (191 kilograms) without options, so customers should notify facilities, shipping, receiving, and installation teams before the unit is delivered.

Customers are strongly advised to ensure that the site is prepared for installation of the UPS R12000 XR. Customers should consider these factors in selecting a site for installation:

- Delivery and unpacking
- Physical considerations
- Electrical service requirements

Delivery and unpacking

The UPS arrives on a pallet. This pallet will be too large to fit through a standard doorway. Customers should have the pallet delivered as close to the installation site as possible. The pallet must be broken down into individual boxes to begin installation.

Physical considerations

As part of the site evaluation, customers should have a facilities engineer evaluate floor loading before installation. The floor should be a commercial floor with uniform load capacity of at least 250 pounds per square foot (1,220 kilograms per square meter) and with a concentrated load capacity of 1,000 pounds (454 kilograms). The UPS alone weighs over 400 pounds (181 kilograms); addition of one or more ERMs and other electronics in the rack can result in a weight of up to 800 pounds (363 kilograms). In addition, customers should evaluate the site for access space requirements.

Because the UPS R12000 XR is a very heavy device, installers should observe guidelines for manual material handling. They should note the safety cautions in the product documentation and be sure to obtain assistance to lift the device components during installation or removal. Before moving the unit, all pluggable modules should be removed to reduce the overall weight of the product.

Electrical service requirements

Electrical service requirements for installation are very specific. Licensed electricians must wire the optional UPS R12000 XR REPO port, wire the ERMs being used to the UPS, and wire the UPS to utility power. Customers must review all electrical service requirements and arrange for a qualified electrician to wire the unit before installation.

Conclusion

The UPS R12000 XR is another example of the HP commitment to provide industry-leading solutions for enterprise customers. With a significantly higher power rating than previous UPSs, the UPS R12000 XR is the first online, "N+x" parallel redundant UPS for HP. By providing redundant power protection, the UPS R12000 XR meets the high-availability demands of today's data centers. In addition, the UPS R12000 XR eliminates system level single points of failure and helps customers build reliable power infrastructures.

For more information

For additional information, refer to the HP power protection solutions website at www.hp.com/products/ups.

Call to action

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